Now-a-days sensors are not limited only to industry or research laboratories but have come to common man’s usage. From kids toys to house hold equipment like washing machine, microwave oven as well as in automobiles, a wide variety of sensors and actuators can be easily seen.

The aim of the present thesis work is to discuss the design, development, fabrication and testing of miniaturized piezoresistive, absolute type, low pressure sensor and flow sensor. Detailed performance study of these sensors in different ambient conditions (including harsh environment such as radiation, temperature etc.) has been reported. Extensive study on designing of thin silicon diaphragms and optimization of piezoresistor parameters is presented. Various experiments have been performed to optimize the fabrication and packaging processes.

In the present work, two low range absolute type pressure sensors (0-0.5 bar and 0-1 bar) and a novel flow sensor (0-0.1 L min-1) for gas flow rate measurement are developed. The thesis is divided into following six chapters.

Chapter 1:

It gives a general introduction about miniaturization, MEMS technology and its applications in sensors area. A brief overview of different micromachining techniques is presented, giving their relative advantages and limitations. Literature survey of various types of MEMS based pressure sensors along with recent developments is presented. At the end, the motivation for the present work and organization of the thesis is discussed.

Chapter 2:

In this chapter, various design aspects of low, absolute type pressure sensors (0-0.5 bar and 0-1 bar) are discussed in detail. Static analysis of the silicon diaphragms has been carried out both analytically as well as through finite element simulations. Piezoresistive analysis is carried out to optimize the piezoresistor dimensions and locations for maximum sensitivity and minimum nonlinearity. All the Finite Element Analyses (FEA) were carried out using

Coventorware software. A novel approach for the selection of resistor parameters (sheet resistance, length to width ratio) is reported . Finally, the expected performance of the designed sensors is summarized.

Chapter 3:

This chapter is divided into two parts. The first part presents the fabrication process flow adopted to develop these low range absolute pressure sensors. Two fabrication process approaches (wet etching and dry etching) which are used to fabricate the thin diaphragms are discussed in detail. Following an overall description, various aspects of the fabrication are elaborated on, like mask design, photolithography process, ion-implantation, bulk micromachining and wafer bonding. The required parameters for implantation doses, annealing cycles, low stress nitride deposition and anodic bonding are optimized through extensive experimental trials.

The second part of this chapter discusses about the different levels of packaging involved in the realization of pressure sensors. Finite Element Analyses (FEA) of Level -0 and Level-1 packages has been carried out using ANSYS software to optimize the packaging materials. Exhaustive experimental studies on the selection of die attach materials and their characterization is carried out. Based upon these studies, the glass thickness and die-attach materials are selected.

Chapter 4:

The chapter discusses the measurement of the fabricated devices. The wafer level characterization which includes I-V characterization, measurement of offset and full scale output is discussed first. And then the temperature coefficient of resistance and offset is measured at wafer level itself. The performance characteristics like sensitivity, nonlinearity, hysteresis and offset of packaged pressure sensors is presented for all the variants (0.5 bar and 1 bar sensors fabricated by KOH and DRIE process) and their comparison with simulated values shows a close match. The measurement of dynamic characteristics using in-house developed test set-up are presented. The next section discussed detailed study about the stability of the developed sensors.

The last part of this chapter reports the harsh environment characterization of the sensors viz. high temperature, humidity exposure, radiation testing etc.

Chapter 5:

The development of a novel micro-orifice based flow sensor for the flow rate measurement in the range of L min-1 is presented in this chapter. The sensing element is a thin silicon diaphragm having four piezoresistors at the edges. A detailed theoretical analysis showing the relationship between output voltage generated and flow rate has been discussed. The flow sensor is calibrated using an in-house developed testing set-up. Novelty of the design is that the differential pressure is measured at the orifice plate itself without the need of two pressure sensors or u-tube which is required otherwise.

Chapter 6:

This chapter summarizes the salient features of the work presented in this thesis with the conclusion. And then the scope for carrying out the further work is discussed.